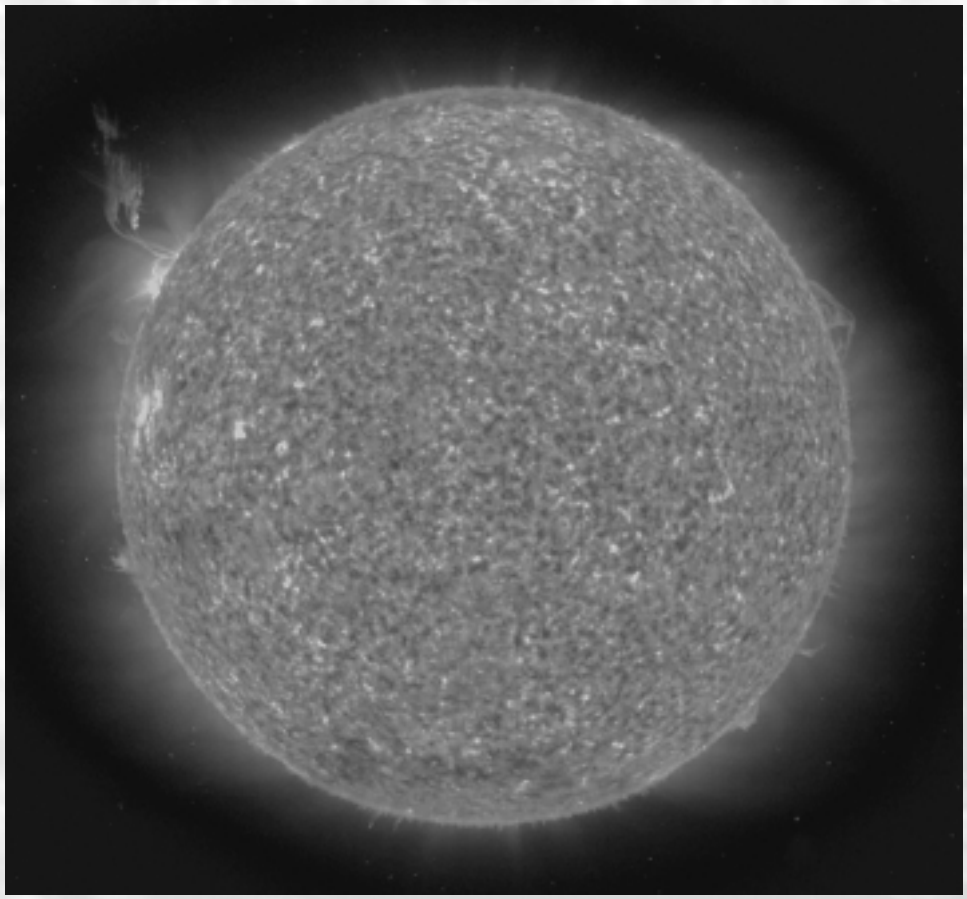


SUNSPOTS

BACKGROUND:

While other ancient cultures did not share this conclusion, by the early 1400's Western religious, philosophical, and observational evidence supported a perfect, unchanging, Earth-centered universe. Therefore, the argument by Copernicus for a Sun-centered universe in 1543 and the amazing appearance of a new star (a nova) in 1572 were extremely challenging to the European world view. However, many more challenges were to come from Galileo Galilei (1564-1642). While Galileo systematically challenged many aspects of contemporary scientific views, his pioneer work in astronomy with a telescope provided evidence to anyone who cared to look with open eyes and open mind that all was not as previously thought in the heavens. Jupiter had moons, Saturn had rings, the Moon had mountains and craters, and the Sun had blemishes–spots that moved across the face of the Sun. Using his telescope, Galileo projected the image of the Sun onto parchment and drew the spots on the parchment. He and others recorded sunspots on many consecutive days, revealing a progressive motion across the Sun. Whether sunspots were on the Sun or satellites circling close to

the Sun was debated for some time. For more information on Galileo and the other observers of sunspots, visit the Web site *http://es.rice.edu/ES/humsoc/Galileo/Things/sunspots.html.*

Many individuals contributed to early research of these strange spots on the Sun in the early 1600's. However, sunspot activity decreased from 1645 until 1715. With so few sunspots, people lost interest. However, in 1843 Heinrich Schwabe discovered the number of sunspots increased and decreased in a cycle. The cycle shows peaks of high sunspot number about 11 years apart. The long period with few sunspots occurred during a period called the "Little Ice Age" in which temperatures decreased globally. This coincidence of the lack of sunspots with a decrease in global temperatures is not sufficient proof of a cause-effect relationship. It does raise interesting questions. More accurate measurements have found the sunspot cycle to be, on average, 11.1 years with ranges between 8 and 16 years.

The causes of solar features such as sunspots have become better understood because of NASA missions such as Ulysses, ACE (Advanced Composition Explorer), Yohkoh, SOHO (Solar and Heliospheric Observatory), and TRACE (Transition Region and Coronal Explorer). However, there is much that scientists hope to learn from future missions such as Solar-B, STEREO (Solar Terrestrial Relations Observatory), SDO (Solar Dynamics Observatory), and Sentinels. Sunspots are regions in the photosphere of the Sun that are relatively cooler than the brighter parts of the photosphere. Sunspots are only about 3700 K compared to 5700 K for the surrounding photosphere. About the size of the Earth or larger, sunspots usually last several days, although very large ones may last for weeks. Sunspots occur at regions of intense local magnetism. Possibly the magnetic fields suppress the movement of hot material upward from the underlying convective zone.

Observations of sunspots led to the conclusion that the Sun rotated. The average time of rotation is 27 days. This isn't the whole story, however. Because the Sun's outer zones are not solid, the equator rotates faster than the poles. At the equator the Sun rotates in about 25 days. At about 40° latitude the rotation takes 28 days and at the poles the rotation is in 36 days.

In this lesson students will be able to observe sunspots safely and discover changes in the number and position of sunspots over time. Students will be able to observe the rotation of the Sun, and, in a math extension, will be able to calculate the period of rotation.

NATIONAL STANDARDS:

National Science Education Standards (NSES)

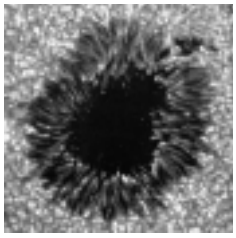
Content Standards (Grades K-4)

- Abilities necessary to do scientific inquiry.
- Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with substances.
- An object's motion can be described by tracing and measuring its position over time.
- The Sun, the Moon, stars, clouds, birds, and airplanes all have properties, locations, and movements that can be observed and described.
- The Sun provides the light and heat necessary to maintain the temperature of the Earth.
- People have always had questions about the world. Science is one way of answering questions and explaining the natural world.
- Men and women have made a variety of contributions throughout the history of science and technology.
- Tools help scientists make better observations, measurements, and equipment for investigations.
- Objects in the sky have patterns of movements.

Benchmarks for Science Literacy-Project 2061

Grades K-2

- Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out.
- Describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.



- Describe and compare things in terms of their number, shape, texture, size, weight, color, or motion.
- Circles, squares, and triangles and other shapes can be found in nature and in things that people build.
- Numbers and shapes can be used to tell about things.
- The Sun can only be seen in the daytime, but the Moon can be seen sometimes at night and sometimes in the day. The Sun, Moon, and stars all appear to move slowly across the sky.
- Shapes such as circles, squares, and triangles can be used to describe many things that can be seen.
- Magnifiers help people see things they could not see without them.
- Simple graphs can help to tell about observations.
- Some events can be predicted well and some cannot.

Benchmarks for Science Literacy-Project 2061

Grades 3-5

- The Earth is one of several planets that orbit the Sun, and the Moon orbits the Earth.
- Scientists' explanations about what happens in the world come partly from what they observe, partly from what they think.
- Telescopes magnify the appearance of some distant objects in the sky, including the Moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye.
- Like all planets and stars, the Earth is approximately spherical in shape.
- The rotation of the Earth on its axis every 24 hours produces the night and day cycle. This turning of the planet makes it seem as though the Sun, Moon, and stars are orbiting around the Earth once each day.
- Tables and graphs can show how values of one quantity are related to values of another.
- Graphical display of numbers may make it possible to spot patterns that are not otherwise obvious, such as comparative size and trends.

National Educational Technology Standards (NETS)

- Students use technology to locate, evaluate, and collect information from a variety of sources.

Mathematics Standards (NCTM)

Grades K-2

- Understand patterns, relations, and functions.
- Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships
- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Represent data using concrete objects, pictures, and graphs.

Grades 3-5

- Build and draw geometric objects.
- Create and describe mental images of objects, patterns, and paths.
- Identify and draw a two-dimensional representation of a three-dimensional object.
- Understand the need for measuring with standard units and become familiar with standard units in the customary and metric systems.
- Collect data using observations, surveys, and experiments.
- Describe, extend, and make generalizations about geometric and numeric patterns.

INSTRUCTIONAL OBJECTIVES:

Students will learn to observe the Sun safely and will discover that the Sun has spots that appear and disappear over time. Students will discover that the Sun rotates. According to their grade level, students need to

be aware of certain facts about the Sun, telescopes, and sunspots.

Grades: Kindergarten-2

1. The nine planets revolve around the Sun, which is the center of our solar system. Even though our Sun is millions of miles away, it is our closest star. The Sun is really a huge bright sphere made up of gas. One hundred nine Earths could fit across the diameter of the Sun. The energy created by the Sun goes out in to space. It gives us heat and light and supports life on Earth. It ultimately is the source of all food and fossil fuel. The Sun also causes the seasons, the climate, the currents in the ocean, the circulation of the air, and the weather on Earth.
2. A scientist named Galileo discovered sunspots about 400 years ago using a telescope. You should never look directly at the Sun even if you are wearing sunglasses or using binoculars or a telescope. You could burn your eyes and damage your eyesight.
3. Sunspots are dark areas on the Sun. They are really magnetic storms on the surface of the Sun. Sunspots are different sizes and shapes. They move across the Sun because the Sun rotates. Sunspots can last from a few days to several weeks. They can affect communication and weather here on Earth.

Grades 3-5:

1. The Sun is made up of hot gases, mainly hydrogen (90%), but has other elements present such as helium, carbon, nitrogen, and oxygen. The Sun's temperature is 10,000 degrees Fahrenheit on the surface and 27,000,000 degrees Fahrenheit in the center. The average distance from the Earth to the Sun is 93 million miles. It takes 8 1/2 minutes for light to travel from the Sun to the Earth. The Sun is large enough to hold over 1 million Earths. The diameter of the Sun is 870,000 miles, 109 times larger than Earth. The Sun is a medium-sized star called a yellow dwarf star. It gives off radio waves, ultraviolet rays, and xrays in addition to visible light. The Sun rotates, or spins on its axis, about once every 27 days. It has 4 layers—the core (center), the radiation layer, the convection layer, and the photosphere (the surface). There are 2 layers above the surface—the chromosphere and the corona.
2. In Italy in 1610, Galileo Galilei, known simply as Galileo, was the first scientist to observe sunspots with a telescope. He did this by making daily observations of the Sun and recording them.
3. Sunspots are irregularly shaped dark areas on the face of the Sun. They are really magnetic storms on the surface, or photosphere, of the Sun. Sunspots can be up to 8 times larger than the size of the Earth and can last a few days to several weeks. They are cooler than the area around them. Sunspots are dark in the center and lighter around the edges. The amount of sunspots changes on an 11-year cycle. Sunspots can cause power outages, interfere with radio communications and satellites, and affect the Earth's weather.

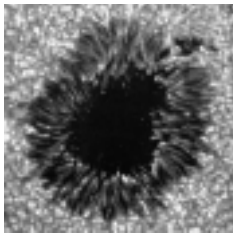
MISCONCEPTIONS ABOUT THE SUN:

- The Sun revolves around the Earth.
- The Sun disappears at night and reappears in the morning.
- The surface of the Sun is solid, smooth, and yellow.
- The "rays" of the Sun are lines out in space.

VOCABULARY:

Grades K-2

binoculars
communications
galaxy
gas
harmful
helpful
magnetic
orbit
revolve
solar
sphere
sunspot
telescope



• • • • • • •